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Structural Dynamics Verification Facility Study

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Cleveland, Ohio

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STRUCTURAL DYNAMICS VERIFICATION FACILITY STUDY

Louis J. Kiraly, Murray S. Hirschbein,
James M. McAleese, and David P. Fleming

SUMMARY

A committee was formed to review and make recommendations regarding the needs for a structural dynamics verification facility. The committee consisted of

Louis J. Kiraly, chairman
David P. Fleming
Murray S. Hirschbein
James D. McAleese
Gerald V. Brown, ex officio

The committee surveyed the gas turbine engine industry, the Air Force, and the Lewis staff to determine whether a facility was needed and, if so, to identify requisite features. All those surveyed were supportive of the proposed facility; they felt that it was a good approach to providing needed research data and that it would benefit the Lewis structures program. Only a few companies would want to make any regular direct use of such a facility if it were available, although others appear to be interested in the possibilities of running occasional special tests. A key finding of the industry survey was that most industrial facilities are used for highly focused research, component development, and the solution of current problems. Industry does not have facilities for use in researching the coupled dynamic response of many components in any way other than by using operating engines in test stands.

Major features for the proposed facility include

- (1) An evacuated (soft vacuum) test chamber
- (2) Multiple shakers and drive motor systems for controlled multipoint test article excitation
- (3) Large-amplitude blade deflection excitation with controlled amplitude and phase about a bladed-disk assembly
- (4) Remotely controlled engine mounts and supports with variable stiffness and damping
- (5) Centralized and comprehensive data acquisition, processing, and control equipment

Major unique capabilities for the proposed facility include

- (1) The ability to excite and measure coupled dynamics between blades and shafting
- (2) The ability to mechanically simulate various dynamical loadings that occur in operational engines (such as transient loading due to hard landings or blade loss)
- (3) The ability to simultaneously excite and measure system responses, including blade-case interactions, rotating-to-static structure force transfer, and dynamics due to varying engine mounting compliance

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The committee found that the experimental capabilities proposed are essential and recommends that a "baseline" facility be constructed with the most basic and needed features. To ensure that the proposed facility will be of continued utility, the committee strongly recommends

- (1) That facility be designed to be as modular and expansible as possible so that it may be readily adapted to developing experimental needs (for fiscal year 1984 and beyond)
- (2) That a dedicated staff be assigned to implement experimental research program goals and to operate and maintain the facility
- (3) That potential requirements for alternative facility sites be addressed in the facility design process

NEEDS

The dynamic behavior of rotating engine structures is not quantitatively well understood. We know that complex dynamic interactions occur between blades, disks, shafting, and the engine casing, but we cannot readily predict them. Future engine advances require that we develop a greater understanding of the dynamics of rotating engine structures so that lighter weight and higher speed engines can be safely designed. Planned work in the structural and rotor dynamics areas focuses on the development of predictive methods that can model engine components and couple their responses. These include methods that are useful for both steady-state harmonic excitation and transient excitation. Eventually it is intended that these methods be extended to treat the entire engine as a unified structural system. Experimental work is needed to investigate and identify dynamic phenomena, to develop and verify theoretical models, and to develop and verify empirical models of phenomena where no adequate analytical model currently exist.

The approach taken by industry with these problems is to build specialized test rigs dealing with each major component; for example, squeeze film damper rigs, spin pits for bladed disks, rotor dynamic test rigs that exclude coupled bladed-disk dynamics, and blade damper facilities. Furthermore the motivation behind the design for these facilities is often to solve existing problems that are present in current engines. As a result there is no comprehensive facility whose prime function is for generic dynamics studies of engine structures. A main difference between the two types of facilities is that the latter is not restricted to existing or anticipated engine components and as such can be designed to provide a wider, but possibly less detailed, spectrum of applications.

Industry does not have facilities for the generic experimental research required. The comprehensive structural measurements needed are exceedingly difficult and costly to make on operating engines, even when mounted in test stands. An experimental facility is clearly needed. The facility should be operated in house to be of most benefit to Lewis programs. The identification of dynamic phenomena will require the ability to rapidly formulate and execute new testing based on acquired data. Furthermore intermediate and final results from in-house, grant, and contract activities will point to other testing that also will need to be "turned around" in a reasonable time frame. It is doubtful that we could obtain the required operational flexibility by contracting for experiments at a facility constructed at a contractor's site. It appears that the most benefit to our programs would result from a facility constructed at Lewis.

FACILITY CONCEPT

The basic capabilities required for the facility can be broken down into three major areas

- (1) Dynamic response of rotating structure, including interactions with nonrotating structures, transient response, and the effects of both distributed and discrete damping
- (2) Blade and shaft dynamic interactions, including the effects of overhung fan stages and prop-fan configurations, blade-case interaction effects, and blade loss dynamics
- (3) Bladed disk system response modeling for high-force-level, large-deflection blade vibrations in typical engine mountings, such as might be encountered during an engine stall or surge

All testing is proposed to be conducted in a vacuum to minimize drive power requirements and to ensure separation of structural dynamic response from possible aerodynamic excitation. Excitations would be purely mechanical in nature and would be provided by a series of highly controlled mechanical shakers or internally by the design of the test article.

Needed dynamic loading capabilities include

- (1) Major transient loadings due to emergency maneuvers, buffeting, and hard landings
- (2) Operational engine loadings due to blade rub dynamics and reverse-thrust conditions
- (3) Internal engine dynamic loadings due to blade loss imbalance, thermal rotor bow, rotor - bearing support misalignment, and strut, bearing, and mount asymmetries

Because the specific nature of future test programs may vary to a considerable degree as our programs evolve, the committee decided to focus on the most basic and general aspects of the facility. With this in mind the committee has also identified a variety of expected and possible expansion features that must be accounted for in the initial design of the facility. The major features of the proposed baseline facility include

- (1) An evacuated test chamber with a vacuum level down to 0.1 psia
- (2) Multiple shakers and drive motor systems capable of controlled multipoint excitation, load simulation, and simulation of parts not physically present in the test chamber
- (3) Remotely controllable and continuously variable stiffness and damping of engine mounts and supports
- (4) Comprehensive data acquisition, processing, and control capabilities with interfaces to on site graphics equipment, a real-time digital simulator(if available), and a high-speed data link to the central computer
- (5) Modularity and expansibility, including the construction of and expansion to satellite work stations for other testing and allowances for possible future program requirements such as prop-fan considerations or cryogenic dampers for shuttle applications

The baseline facility and the most likely expansion features are detailed in table I. Considerations of the potential expansions will require that siting requirements be carefully reviewed during the design process.

The baseline facility will address many of the research topics proposed for future work in structural and rotor dynamics. These include

- (1) Validation of transient analysis methods for blade loss dynamics, blade rub events, and blade-case interactions
- (2) Validation of dynamics analysis for overhung fan stages, including some aspects of prop whirl, one-nodal-diameter bladed-disk modes and the general coupled blade-disk-shaft problem
- (3) Validation of modeling methods for treating rotating-to-static structure interfaces, including methods for predicting dynamic bearing stiffnesses, force transmission through dampers and bearings for simulated wing and pylon motion, and blade-case interaction dynamics
- (4) Determination of stiffness and damping distributions on structural dynamic behavior, including distributed structural damping on rotating members and discrete damper devices, correlation with critical speeds, and parametric studies of mount stiffness and damping effects
- (5) Bearing and seal effects, including tolerance to structural deflections, the effects of alternative bearing stiffness and placement, and the effects of asymmetric loading due to misalignment or structural deflections
- (6) Preliminary evaluation of engine instrumentation, including photo-optical instrumentation, data communication from rotating members, laser balancing, and evaluations of blade-mounted aerodynamic probes to determine their performance in the absence of aerodynamic forces

SURVEY

Facility schematics and plans for a fully expanded facility (i.e., as opposed to the baseline facility) were presented to seven industrial concerns, Lewis personnel, and the Air Force. Members of the committee met with all those surveyed except Garrett (with whom the survey was conducted by telephone and mail). Meeting results were used to upgrade and redefine the capabilities of a fully expanded facility. All industrial contacts responded in writing after reflecting upon our presentations and earlier discussions. The facility presentation made at these meetings is included as appendix A. The people contacted and the companies that they represented are as follows:

Ray Liss, Pratt & Whitney
Michael Stallone, General Electric
A. V. Srinivasen, United Technologies Research Center
William Parker, Detroit Diesel Allison
Hugh Gaylord, Teledyne
Lee Matsch, Garrett
Alan Krauter, Shaker Research
Zeke Gershon, Wright-Patterson Air Force Base

In the meetings with industry we focused on the maximum capability possible for the facility and asked the following questions:

- (1) Should Lewis endeavor to build such a facility?
- (2) What are the research areas that require a facility?
- (3) Are there better ways to achieve our long-term objectives than with the proposed facility?
- (4) What features have we left out?
- (5) What features most need to be included as part of the baseline facility?
- (6) What kind of facilities do you have and how do you use them?
- (7) Could you make use of the proposed facility for nondevelopmental programs if it were available?

The key findings from the survey are as follows:

(1) All those surveyed agreed that the proposed facility represented the most reasonable approach to achieving long-term structures program goals.

(2) Further they felt that the proposed facility would provide useful and unique research data. There was disagreement on some of the particulars regarding the most important areas of work. Most felt that the fully expanded facility was ambitious and that it was reasonable to first establish the baseline facility.

(3) Most of the respondents indicated that they would, at most, be infrequent users of the facility. We pointed out that NASA's charter and the Unitary Wind Tunnel Act (the legal precedent for industrial use of NASA facilities) would only permit bona fide research projects and not developmental or problem solving use of such a facility. Proprietary research would still be possible, however; and there was some limited interest for industrial use in this way.

(4) All displayed an interest in the facility and indicated a desire to participate in further planning. The committee feels that the collective experience of the industrial members would be beneficial to the detailed design planning of this facility.

(5) An on-site review of many of the industry's facilities and round table discussions have indicated that industrial facilities are primarily oriented toward component development. These facilities have been built and are operated to conduct highly focused component research and to solve operational problems.

(6) Industry does not have comprehensive facilities for researching the structural dynamic interactions of coupled systems. Furthermore only a few facilities can really be considered applicable to even general component research. Although, capabilities exist for instrumenting operating engines in various configurations and operating environments, these test facilities are costly to operate, the types of measurements are extremely limited, and it is very difficult to do generic research in this type of facility.

(7) Several common interests were expressed by the respondents for possible experimental programs:

- (a) The capability to determine the effects of both discrete and distributed damping on rotor system stability as well as the actual structural damping levels
- (b) The capability to determine the effects of one-nodal-diameter bladed-disk modes on coupled blade, disk, and shaft dynamic behavior

- (c) The capability to excite blade deflection of rotors mounted on realistic shafting so that blade deflection and shaft and disk coupling effects can be evaluated
- (d) The capability of conducting parametric studies of the effects of mounting stiffness and damping on rotating system behavior
- (e) The inclusion of some limited aerodynamic capabilities for such things as shaft damping, effects of case distortion, contributions to nonsynchronous vibration phenomena, prop whirl, and seal stability. Although all the respondents were interested in this, they all noted the difficulties in providing aerodynamic effects because of the power level requirements and other trade-offs in facility capabilities.

(8) Most of the industrial respondents felt that shaft whirl and one-nodal-diameter mode blade vibrations represented the most significant problems in the coupled blade, shaft, and disk area. Other potential problems are currently avoided by conservative design practice. It was not clear whether the industry felt that this would still be true in fiscal year 1984 and later.

(9) Other common interests expressed in most of the industry meetings were

- (a) A definite concern for the day-by-day operational support required, particularly if they were to request use of the facility
- (b) An interest in the application of electronic simulation techniques to simulate engine component structures not physically present in the test chamber. Committee members were careful to point out that the simulator was looked on as a desirable feature but that its use was not pivotal to the facility concept.

RESOURCE REQUIREMENTS

The general character of the proposed baseline facility has remained much the same as it was before the study although specific details of its operation and potential programs have changed. The rough estimate of facility construction costs as presented in the 1981 Lewis book "Construction of Facilities" (January 15, 1981, Volume 2) also remains the same as shown in the attached appendix B. A total of \$4 850 000.00 in fiscal year 1984 dollars was estimated.

Operational support requirements will depend greatly on how fully the facility's use would be scheduled. Based on half-time use, the following annual manpower costs were estimated:

- (1) Full-time engineering support, 2 man-years
- (2) Full-time technician support, 6 man-years

If the possibility for industry use of the facility were ruled out, these manpower requirements would drop slightly because there would be less need to maintain detailed test facility interface standards, schedules, and usage documentation.

Annual operating costs for the facility were estimated to be \$200 000 in fiscal year 1984 dollars (exclusive of the costs associated with staffing the facility). These costs are based on the fabrication of a single bladed-disk and shaft test article every 2 years and a single rebuild or modification of an existing test article every year. These test articles would mostly be minimally featured, greatly simplified research test articles with controlled attributes. Routine maintenance costs were also estimated. The cost estimates break down as follows:

Routine facility maintenance	\$75 000
(mostly provided by the full-time staff)	
Test article fabrication	\$80 000
(bladed disk and shaft system)	
Test article rebuild	\$45 000
Total cost	\$200 000

No procurement of full-size hardware from an engine is anticipated. Such hardware is assumed to be available from other NASA programs or to be borrowed from the Air Force or the industry.

Expansion capabilities beyond the baseline facility would require subsequent construction-of-facilities funding, funding from other research groups wishing to use the facility (i.e., turboprop program), and limited diversion of research and development resources for test article modifications.

TABLE I. - FACILITY CAPABILITIES

Baseline facility	Expansion features
Buildup area and single evacuated test chamber (10.1 psia)	Multiple satellite test chambers
Single rotor drive	two-spool drive
Full-size engine articles 8-foot diameter to 4000 rpm 4-foot diameter to 20 000 rpm	Turboprop systems
Multiaxis, multipoint shaker control systems, air jet excitation, and hydraulic ram	Additional shakers, piezocrystalline exciters
Large-amplitude, controlled-phase, blade deflection excitation	Large-amplitude support motion excitation
Rotating structures mounted and driven off of rigid bed plates	Flexible, distributed-property bed plates to simulate frame attachment
Highly centralized data collection and control with standard digital data links to test chambers	50 Percent of control room space available for expansion and alternative instrumentation
Strain gages, accelerometers, proximity probes, and holography	Optical data link systems
Mathematical real-time simulation of parts not present in the facility	Possible expansion for programs to study foreign-object damage, cryogenic shuttle components geared fans, and turboprops (gearbox, pitch change, coriolis forces, and shaft dynamics), and other potential programs
Remotely controlled and continuously variable support stiffness and damping	

APPENDIX A

VIEWGRAPH PRESENTATION MADE TO INDUSTRY

STRUCTURES PROGRAM GOALS

- ANALYTICAL TOOLS TO MODEL ENGINE COMPONENTS AND TO DYNAMICALLY COUPLE THEIR RESPONSES
 - BLADED ASSEMBLIES ON ELASTIC SHAFTS
 - TRANSIENT DYNAMICS OF ROTATING STRUCTURES
 - FORCED RESPONSE DUE TO AIRFRAME INTERACTION
- ANALYTICAL TOOLS THAT TREAT THE ENTIRE ENGINE AS A UNIFIED STRUCTURAL SYSTEM
 - CURRENTLY LIMITED OR NONEXISTENT
 - EMPIRICAL GUIDELINES NEEDED
- EXPERIMENTAL VERIFICATION IS ESSENTIAL
 - TO GUIDE ANALYTICAL DEVELOPMENT
 - TO DEMONSTRATE ANALYSIS EFFECTIVENESS
 - TO PROVIDE EMPIRICAL MODELS WHERE ANALYSIS FAILS

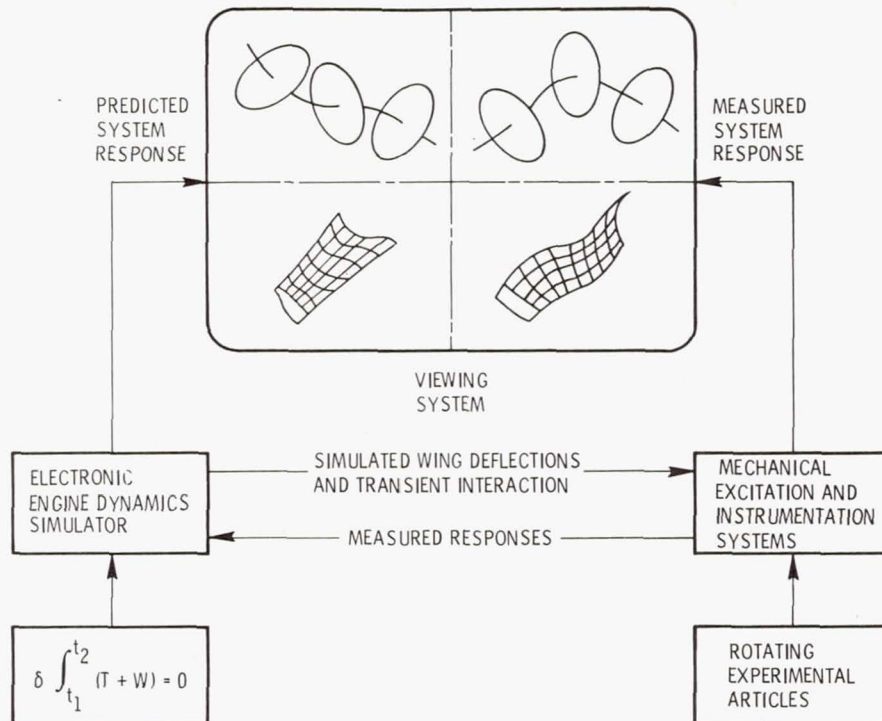
NEEDS FOR EXPERIMENTAL VERIFICATION

- BLADED-DISK SYSTEM RESPONSE
 - HIGH-FORCE-LEVEL EXCITATION RESPONSE
 - TYPICAL ENGINE MOUNT CONFIGURATIONS
- DYNAMICS OF ROTATING STRUCTURES
 - TRANSIENT RESPONSE
 - DISTRIBUTED STRUCTURAL DAMPING AND DISCRETE DAMPING LEVELS
 - INTERACTION WITH NONROTATING STRUCTURES (SUCH AS THE CASING AND PYLON)
- BLADED-DISK - SHAFT INTERACTION
 - OVERHUNG FAN STAGE AND PROP-FAN CONFIGURATION
 - BLADE-CASE INTERACTION EFFECTS
 - BLADE LOSS DYNAMICS

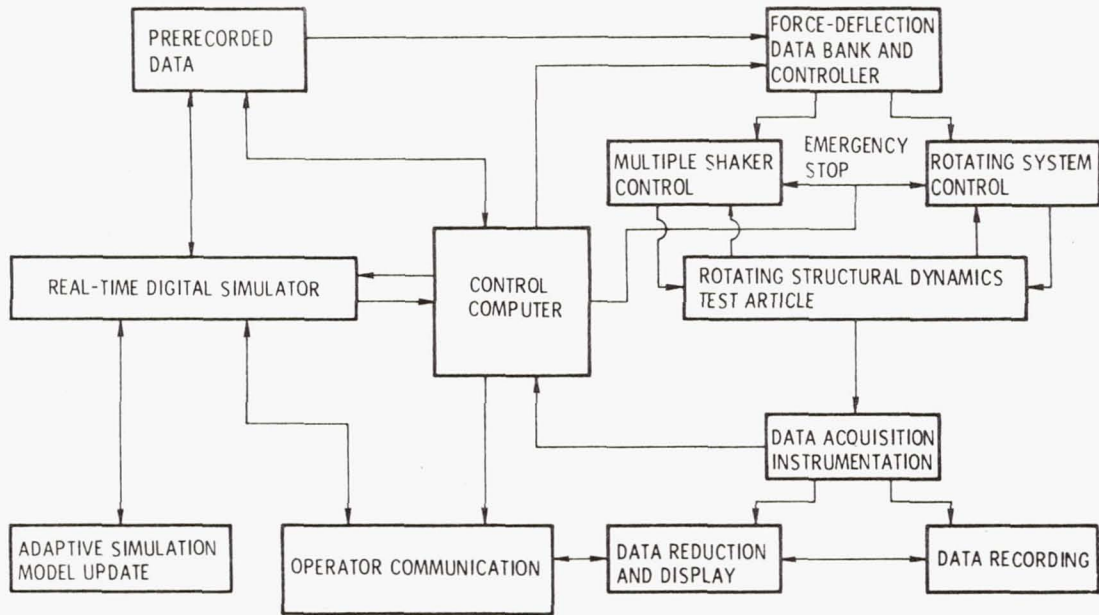
FACILITY USAGE GOALS

- STUDY OF HIGH-SPEED, FLEXIBLE, DAMPED AND MULTISHAFTED ROTATING SYSTEMS ON NONRIGID SUPPORTS
- VERIFICATION AND UPDATING OF STRUCTURAL DYNAMICS THEORY AND ANALYTICAL MODELS
- ESTABLISHMENT OF EMPIRICAL METHODS AND MODELS WHERE ANALYTICAL METHODS ARE CURRENTLY INADEQUATE

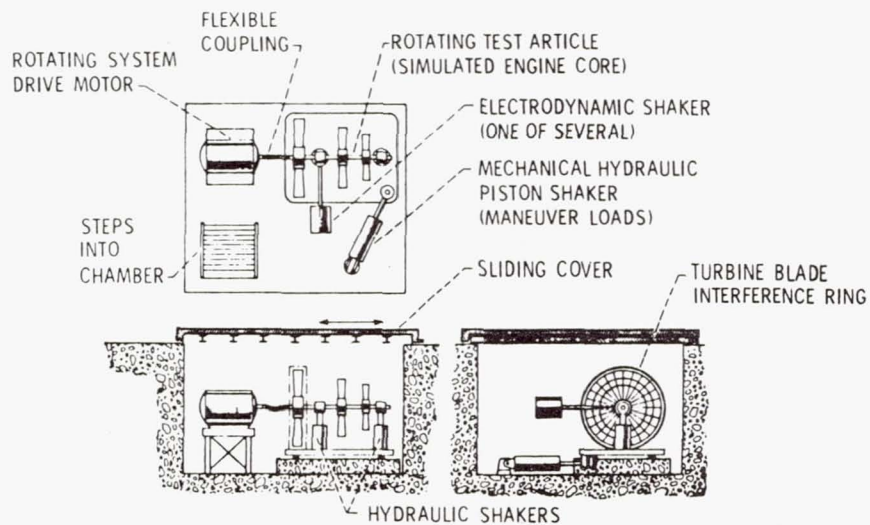
STRUCTURAL DYNAMICS VERIFICATION FACILITY



ENGINE STRUCTURAL DYNAMICS VERIFICATION FACILITY



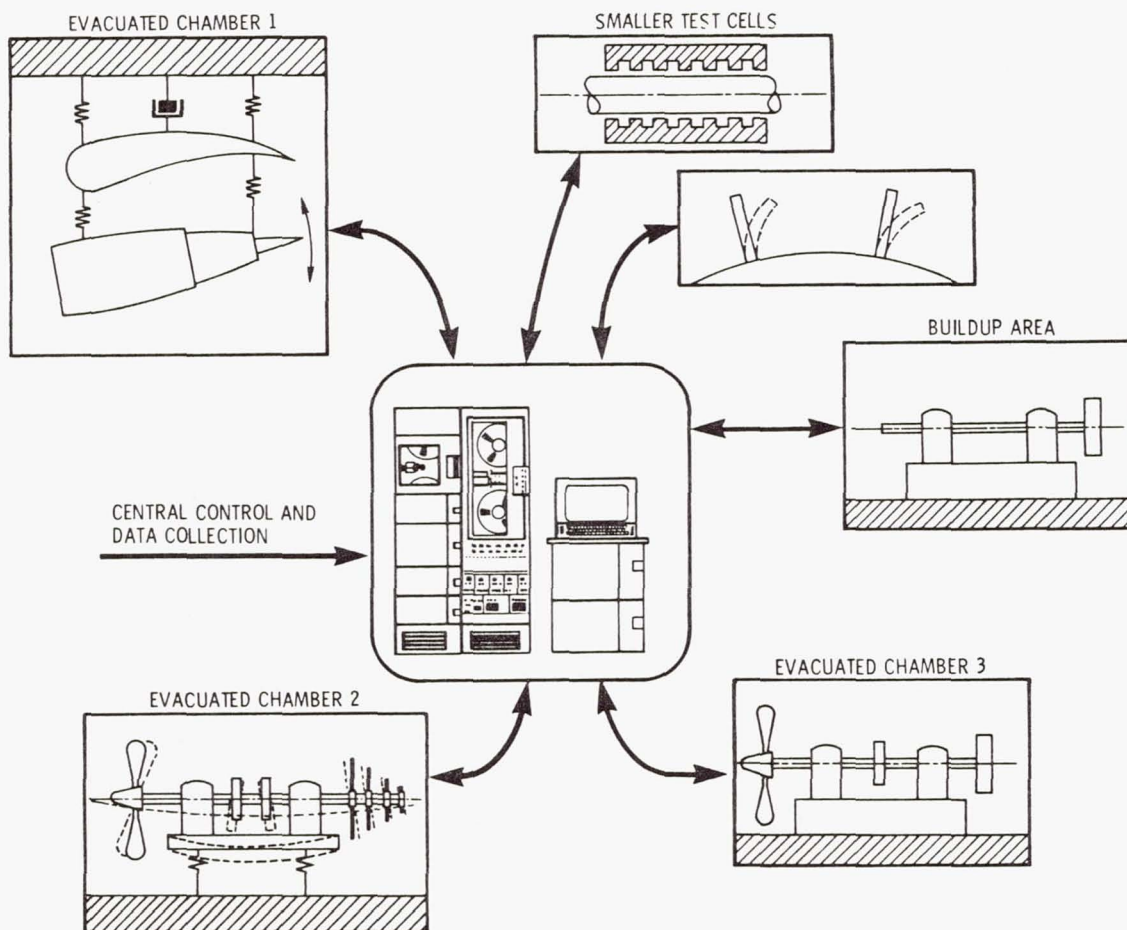
LOW PRESSURE CHAMBER SCHEMATIC



POTENTIAL MAJOR FEATURES

- CENTRALIZED DATA COLLECTION AND CONTROL
 - COMPREHENSIVE DATA ACQUISITION, DATA PROCESSING, AND CONTROL PACKAGE
 - INTERFACE TO A REAL-TIME DIGITAL SIMULATOR
- MULTIPLE SHAKERS AND DRIVE MOTOR SYSTEMS
 - CONTROLLED MULTIPOINT EXCITATION
 - SIMULATION OF ENGINE STRUCTURES NOT PHYSICALLY PRESENT
- SATELLITE WORK STATION CONCEPT
 - EACH TIED TO A COMMON DATA COLLECTION AND CONTROL AREA
 - EVACUATED TEST CHAMBERS OF PROGRESSIVE COMPLEXITY
 - BUILDUP AND WORK AREAS
- DESIGNED FOR MODULARITY AND FUTURE APPLICATIONS
 - POSSIBLE FOREIGN-OBJECT-DAMAGE TEST CAPABILITY
 - LARGE PROP-FAN ROTORS
 - TRANSIENT AERODYNAMICS RESEARCH IN A SCALED SATELLITE RIG
 - LARGE-DIAMETER DAMPERS

SATELLITE WORK STATION CONCEPT



DYNAMIC LOAD SIMULATION CAPABILITY

- SIMULATION OF MAJOR TRANSIENT LOADINGS
 - EMERGENCY MANEUVER LOADS
 - BUFFETING
 - HARD LANDINGS
 - BLADE LOSS
- OPERATING ENGINE LOAD SIMULATION
 - CRUISE
 - MANEUVER
 - TAKEOFF
 - BLADE RUB

POTENTIAL RESEARCH AREAS

- TRANSIENT ANALYSIS VERIFICATION
 - BLADE LOSS DYNAMICS
 - BLADE RUB MODELING
 - BLADE-CASE VIBRATION INTERACTION
- OVERHUNG FAN STAGES
 - SHAFT WHIRL MECHANICS
 - GYROSCOPIC EFFECTS
 - COUPLED BLADE-DISK-SHAFT DYNAMICS
- GEARED-PROP AND GEARED-FAN DYNAMICS
- ROTATING-TO-STATIC-STRUCTURE INTERFACE MODELING
 - DETERMINATIONS OF DYNAMIC BEARING STIFFNESS
 - FORCE TRANSMISSION FROM ROTATING TO STATIC MEMBERS
 - FORCING DUE TO SIMULATED WING AND PYLON VIBRATIONS, BUFFETING, AND MANUEVER LOADING
- COUPLED STAGE VIBRATIONS
 - NONSYNCHRONOUS VIBRATIONS
 - INTERSTAGE RESONANCES

POTENTIAL RESEARCH AREAS (CONCLUDED)

- STIFFNESS AND DAMPING DISTRIBUTIONS
 - REPRESENTATIVE VALUES
 - CRITICAL SPEED CORRELATIONS
- BEARING AND SEAL EFFECTS
 - TOLERANCE TO STRUCTURAL DEFLECTION
 - ALTERNATIVE BEARING STIFFNESS AND PLACEMENT
 - ALTERNATIVE THRUST BEARING LOCATION AND LOAD PATHS
- PRELIMINARY EVALUATION OF ENGINE INSTRUMENTATION
 - PHOTO-OPTICAL PROBES
 - DATA COMMUNICATION WITH ROTATING MEMBERS
 - LASER BALANCING

SOME POSSIBLE "SPINOFFS"

- OTHER RESEARCH AREAS
 - LABYRINTH SEAL DYNAMICS AND STABILITY BOUNDARIES
 - LARGE-DIAMETER, HIGH-SPEED DAMPER STUDIES
 - LUBRICATION SYSTEM OPERATION STUDIES
 - PARAMETRIC ENGINE DYNAMICS MODELS FOR CONTROLS AND OPTIMIZATION
- DIRECT INDUSTRY INVOLVEMENT
 - INDUSTRIAL USE ON A RENTAL BASIS (OUT-OF-POCKET EXPENSES ONLY) WITH PROPRIETARY RIGHTS TO DATA
 - COOPERATIVE NEW TECHNOLOGY PROGRAMS
 - CONTRACT RESEARCH PROGRAMS


SOME OTHER POTENTIAL FEATURES

- MULTISHAKER, MULTIAXIS CONTROL SYSTEMS
- SIMULATED CASE DEFLECTIONS
- PROVISIONS FOR BLADE LOSS DYNAMICS TESTING
- PROVISIONS FOR BLADE RUB DYNAMICS TESTING
- LARGE-AMPLITUDE BLADE EXCITATION
- SIMULATED WING INERTIA WITH VARIABLE MASS BEDPLATES
- REMOTELY CONTROLLED, VARIABLE MOUNTING STIFFNESS FOR PARAMETRIC STUDIES
- MOUNTING OF TEST ARTICLES FROM ABOVE OR BELOW
- INNER SPOOL DEFLECTION MEASUREMENTS
- MANIPULATOR-ARM-MOUNTED OPTICS FOR EXAMINING GROSS DYNAMIC BEHAVIOR

STRUCTURAL DYNAMICS VERIFICATION

FACILITY SUBMISSION TO THE 1981

LEWIS CONSTRUCTION-OF-FACILITIES HANDBOOK

 Facility Project - Brief Project Document						CONTROL NO.							
PROJECT TITLE Construction of Engine Structural Dynamics Verification Facility (51)						INSTALLATION/PROGRAM OFFICE LeRC/Cleveland/AST							
						DATE 12-31-80							
						REVISION NO. C							
APPROVED FACILITY PROJECT COST ESTIMATE	ITEMS (List) Rotating systems Excitation systems Instrumentation, control & data reduction Supporting structures & facility mods. Digital simulation for parametric studies				AMOUNT \$4,850,000								
	RELATED COST DATA (Not included in this Approved Facility Project Cost Estimate but required to make the facility initially operable)												
	RELATED COSTS INVOLVED <input checked="" type="checkbox"/> YES (Identify) <input type="checkbox"/> NONE												
	OTHER RELATED EQUIPMENT		ITEM		AMOUNT								
	TO BE PURCHASED		ITEM		AMOUNT								
CATE- GORY Program related		WORK Construction		FUTURE FUNDING		ACTIVATION							
FUND SOURCE <input type="checkbox"/> R&D <input type="checkbox"/> R&PM <input checked="" type="checkbox"/> OF F		IDENTIFICATION FY 1984 Project _____		OTHER REAL ESTATE		OTHER (Specify) Study							
SCOPE/DESCRIPTION (Project write-up dated _____ and sketch dated _____ attached.) This project will consist of a multiple shaft/rotor/bearing/damper simplified dynamic simulator with programmed force-deflection provided by stokers and using a variable stiffener mechanical rig powered by an electric motor. An electronic engine structural simulator will be built in conjunction with the mechanical facility so that simultaneous real-time computer graphic comparisons can be made. All aspects of this project are covered by the Institutional Environmental Impact Statement for LeRC approved 8-25-71. Randolph-Sheppard Act Amendments of 1974 are not applicable to this project. Impact on Existing Facility Capability: a. None _____; b. Decrease /Increase <u>X</u> _____; c. Environmental impact <u>See text</u> _____													
BASIS OF NEED ("Unforeseen Programmatic" Project Analysis Sheet dated _____ attached, if applicable.) As part of the increased effort in engine structures, a structural dynamics facility is required to study the behavior of high speed, flexible, damped rotating machinery. The proposed facility will give Lewis a new capability. Current analytical or modeling techniques are inadequate for accurately predicting structural dynamic behavior and effects of engine structural and mechanical modifications on overall engine system performance because of the complex interactions involved. This is particularly true when studying transient phenomena such as blade loss transient dynamic behavior and system response to simulated gust and maneuver loads, hard landings and transient (continued)													
SCHEDULE DATES	DESIGN	PER	START	1-82	PROJECT APPROVAL	SIGNATURE AND TITLE	DATE						
			COMPL	4-82		SUBMITTED BY	Daniel J. Shramo, Director of Engineering Services						
		FINAL	START	1-83					CONCURRENCE BY	SIGNATURE AND TITLE	DATE		
			COMPL	8-83									
	CON- STRUCTION	AWARD	1-84	BX CON- CURRENCE		SIGNATURE AND TITLE	DATE						
			COMPL					8-85					
		REQUIRED OPERATIONAL						PROJECT STIPULATIONS:					
								(a) Notification of bid per NHB 7320.1, Par. 213.(b) Send copy to NASA Hq. Code BX:(c) _____.)					

84LCIA

Construction of Engine Structural Dynamics
Verification Facility (51)

BASIS OF NEED - (continued)

unbalance. The facility will permit verification testing of structural system response prediction methods as they are developed.

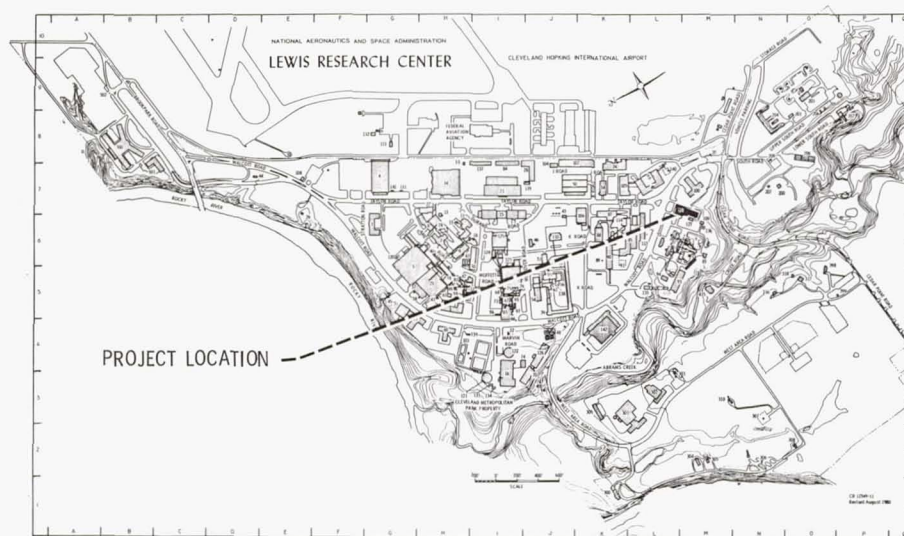


Figure 1. - Location plan.

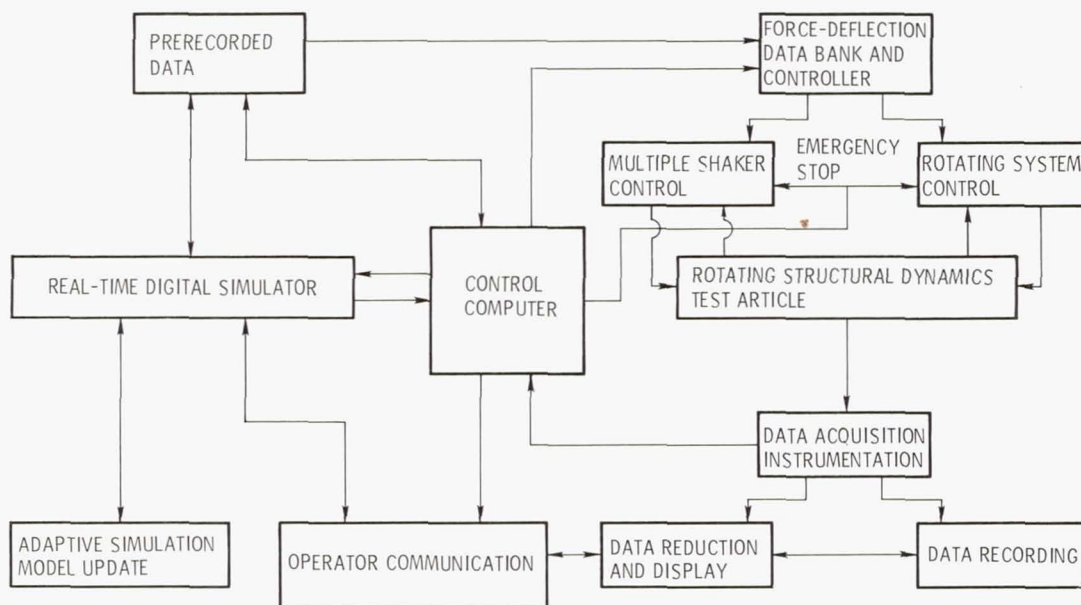


Figure 2. - Block diagram of engine structural dynamics verification facility.

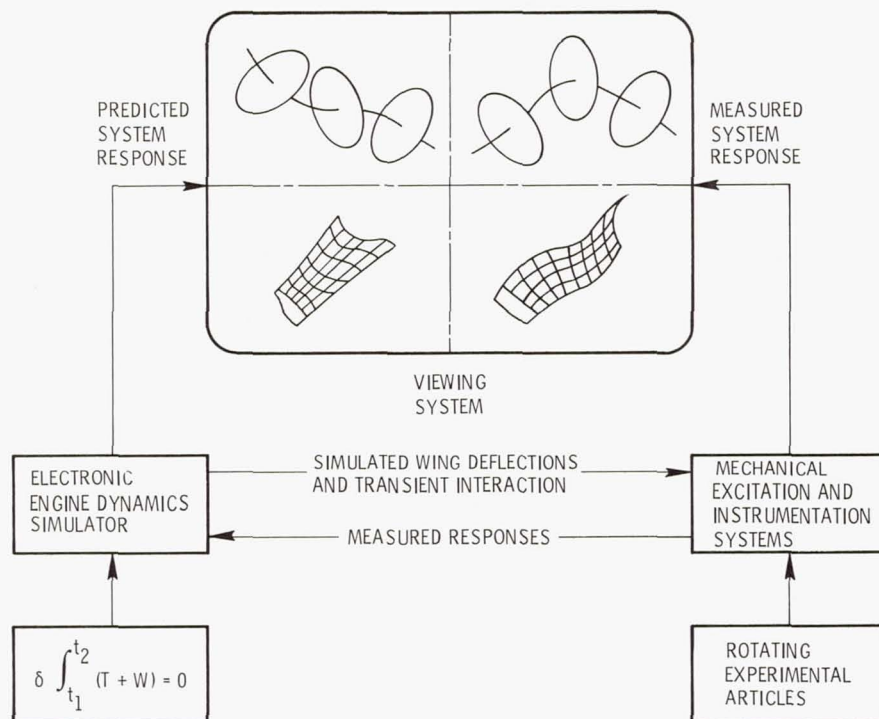


Figure 3. - Engine structural dynamics verification facility concept.

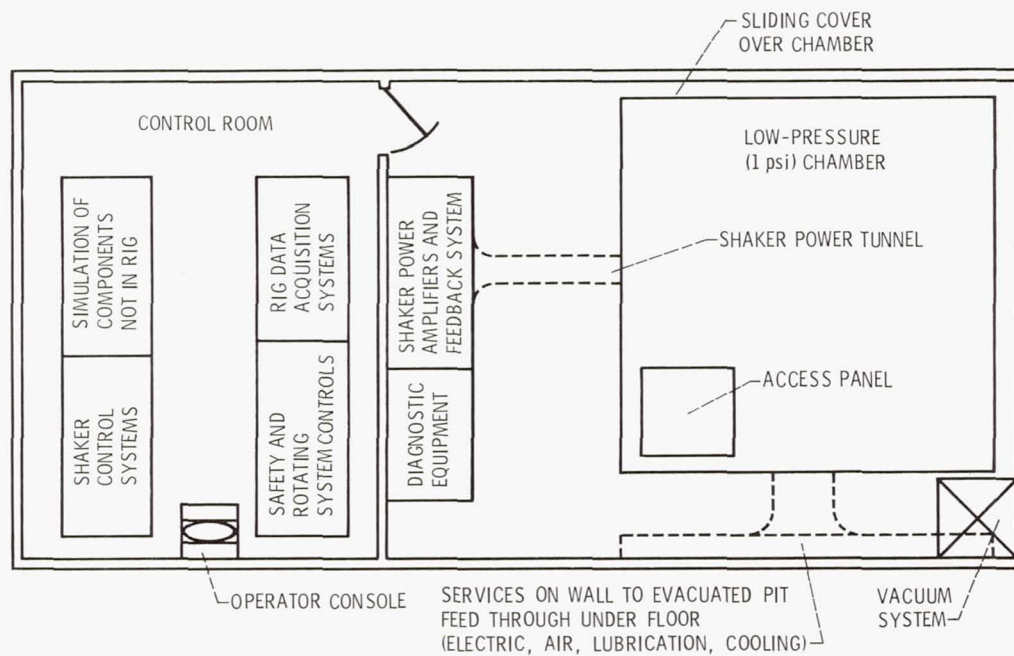


Figure 4. - Plan view of structural dynamics verification facility.

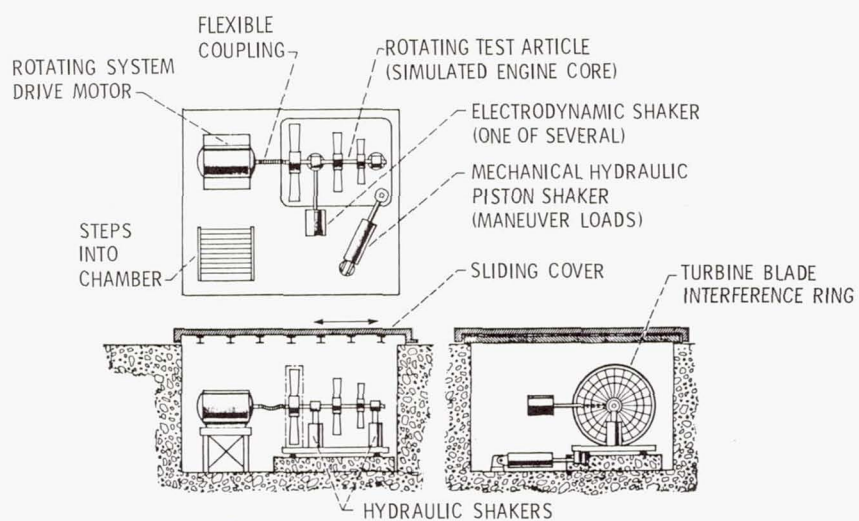


Figure 5. - Schematic of low-pressure chamber.

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				11. Contract or Grant No.	
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546				13. Type of Report and Period Covered Technical Memorandum	
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15. Supplementary Notes					
16. Abstract <p>The needs for a structural dynamics verification facility to support structures programs at the NASA Lewis Research Center were reviewed, an industry survey was conducted, and final recommendations were made. All those surveyed felt that the proposed facility would be needed to support long-range structures program goals at Lewis. Furthermore they felt that there were not any existing facilities which could be used for the requisite generic research. Most of the industry-operated facilities are used for highly focused research, component development, and problem solving - and are not used for the generic understanding of the coupled dynamic response of major engine subsystems. It has been recommended that the facility be constructed in fiscal year 1984. Some of the unique capabilities for the proposed facility include the ability to both excite and measure coupled structural dynamic response of elastic blades on elastic shafting, the mechanical simulation of various dynamical loadings representative of those seen in operating engines, and the measurement of engine dynamic deflections and interface forces caused by alternative engine mounting configurations and compliances.</p>					
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